DATA PRODUCT SPECIFICATION FOR TEMPERATURE ARRAY IN SPATIAL GRID

Version 1-03
Document Control Number 1341-00130
2020-04-03

Woods Hole Oceanographic Institution
Woods Hole, MA
www.whoi.edu

in Cooperation with

University of Washington
Oregon State University
Rutgers University

Document Control Sheet

Version	Date	Description	Author
0-01	2012-11-06	Initial Draft	G. Proskurowski
0-02	2013-03-14	Draft after Focused Review with input from Merrie Beth Neely, Mike Vardaro, Bill French and Karen Stocks	G. Proskurowski
0-03	2013-04-11	Minor modifications following Formal Review	G. Proskurowski
0-04	2013-04-12	Minor revisions in preparation for approval	M. Gibney
1-00	2013-05-10	Initial release	E. Chapman
1-01	2013-06-13	Minor modifications in the format of final data product following ION-beta interactions	G. Proskurowski
1-02	2017-04-17	X and Y coordinates swapped in Appendix C to match calibration data. X now points towards the sensor heading. Added conversion from Redmine #4392. Added frame geometry images and info.	F. Knuth, M. Vardaro, D. Manalang
1-03	2020-04-03	Corrected typos in geometry image; removed coordinate table; added reference to find coordinate information in the calibration files, details on x,y,z coordinates of instrument, and how the “heading” coefficient is referenced and calculated. Corrected formula representation for voltage. Made various clarifications and grammar corrections throughout document.	W. Ruef, O. Kawka

Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer: ____________________

Date: 2013-05-10

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

OOI CI Signing Authority: ____________________

Date: ____________________

Table of Contents

1 Abstract

This document describes the computation used to calculate the OOI Level 1 Temperature Array in Spatial Grid data product from the TMPSF instrument, custom built thermistor array with a RBR XR-420 data logger. This data product is a simple parsing of calibrated temperature values measured by 24 thermistors positioned on the instrument. The instrument temperature output is a “real-time” streaming value that has internally been converted from raw voltage to scientific units using the onboard calibration coefficients of the instrument.

2 Introduction

2.1 Author Contact Information

Please contact help@oceanobservatories.org for more information concerning the computation and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name

The OOI Core Data Product Name for this product is
- TEMPSFL

The OOI Core Data Product Descriptive Name for this product is
- Temperature Array in Spatial Grid

2.2.2 Data Product Abstract (for Metadata)

The OOI Level 1 Temperature Array in Spatial Grid core data product is the measured temperature at each of 24 thermistors arranged in a spatial array.

2.2.3 Computation Name

Not required for data products.

2.2.4 Computation Abstract (for Metadata)

This algorithm parses the OOI Level 1 Temperature Array in Spatial Grid core data product, from the instrument data string.

2.2.5 Instrument-Specific Metadata

See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms

Synonyms for this data product are
- Vent temperature

2.2.7 Similar Data Products

Similar products that this data product may be confused with are “Vent Temperature-RASFL” or “TRHPH-Temperature” which are measured on different instrument classes and calculated using different methodologies.

2.3 Instruments

For information on the instruments from which the L1 Temperature Array in Spatial Grid core data product inputs are obtained, see the TMPSF Data Processing Flow document (DCN 1342-00130). This document contains information on instrument classes and make/models; it also describes the flow of data from the instrument through all of the relevant QC, calibration, and data product computations and procedures.

Please see https://oceanobservatories.org/instruments/ for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents

RBR: OEM Command Reference for RBR Submersible Data Loggers

Stored on Alfresco:

OOI > Reference Archive > Data Product Specification Artifacts > 1341-00130_TEMPSFL

As RBR_logger_OEM-ref.pdf .

2.5 Terminology

2.5.1 Definitions

Not Applicable.

2.5.2 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). The following acronyms and abbreviations are defined here for use throughout this document.

2.5.3 Variables and Symbols

The following variables and symbols are defined here for use throughout this document.

t1 Temperature, °C, at thermistor #1 (furthest from logger)
…
t24 Temperature, °C, at thermistor #24 (closest to logger)

3 Theory

3.1 Description

Temperature is measured at 24 locations along the thermistor string. Onboard the data logger, the raw measurements are converted to °C using vendor-provided and vendor-installed calibration coefficients associated with each individual thermistor. The position of each thermistor is provided in the metadata, using <x y z> coordinates in centimeters. See Appendix C for additional thermistor position details.

3.2 Mathematical Theory

Not Applicable.

3.3 Known Theoretical Limitations

Not Applicable.

3.4 Revision History

Revisions to test data set based on ION-beta interactions.

4 Implementation

4.1 Overview

Instrument output in °C is parsed into 24 individual thermistor temperature measurements. The instrument agent driver for TMPSF converts the raw battery voltage into volts.

4.2 Inputs

- Raw Seafloor Temperature ASCII string
- Raw battery voltage engineering data

Input Data Formats:
The instrument provides a "real-time" output formatted as an ASCII text string:

TIM YYMMDDhhmmss xx.xxxx xx.xxxx xx.xxxx … xx.xxxx BV: xx.xxxx SN: xxxxxx FET<CR><LF>

The inputs to be parsed, the series of 24 xx.xxxx temperature values, are formatted as space delimited 4 decimal place floating point value (%.4f), followed by battery voltage "BV:" (%.4f) and Serial Number "SN:" (%.0f).

Example TMPSF "real-time" data output:

TIM 130314234613 21.6458 21.6170 21.4511 21.6136 21.7019 21.5384 21.5810 21.5981 21.5636 21.6112 21.4667 21.6050 21.6453 21.6544 21.5423 21.6627 21.5840 21.5927 21.6397 21.6951 21.6133 21.5960 21.6429 21.5954 BV: 11.5916 SN: 021968 FET<CR><LF>

4.3 Processing Flow

The specific steps necessary to create all calibrated and quality-controlled data products for each OOI core instrument are described in the instrument-specific Processing Flow documents (DCN 1342-00130). These processing flow documents contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures.

The processing flow for the pressure computation is as follows:

Step 1:
The instrument driver receives the data.

Step 2a:
The instrument driver parses the data stream to obtain Temperatures (t1 – t24) to create the L1 data product of 24 parameters, each parameter representing a temperature value with identical formats but unique spatial position (see Appendix C).

Step 2b:
The instrument driver parses the data stream to obtain the raw battery voltage (counts) and transforms the values into voltage using the following:

Voltage = 0.254170 + (0.0816485 * 84) = 7.112644*V

4.4 Outputs

The outputs of the parsing are
- Time, YYMMDDhhmmss (not used, use DigiPort timestamp for time)
- Temperature, °C, %.4f. (goes to L0)
- Greater of Input voltage and Battery voltage, V, %.4f. (goes to metadata)
- Serial Number, SN, %.0f. (goes to metadata)

L1 product includes the 24 L0 Temperature Array in Spatial Grid product merged with the time stamp information. There are 24 temperature outputs, t1:t24, corresponding to the 24 thermistor pods on the instrument. The 24 temperature values can be stored in an array but should have the full functionality during plotting and downloads of 24 parameters. The spatial arrangement of these 24 thermistors is defined in a matrix.

- L1 metadata includes spatial position of each thermistor, as a matrix of <thermistor# x y z> where x, y, z are coordinate positions in cm from an origin at the seafloor beneath thermistor #2. See Appendix C for details on thermistor positions on instrument builds.

See Appendix B for a discussion of the accuracy of the temperature output.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations

There are no numerical programming considerations for this computation. No special numerical methods are used.

4.5.2 Computational Requirements

Not Applicable.

4.6 Code Verification and Test Data Set

The code will be verified using the test data set provided, which contains inputs and their associated correct outputs. CI will verify that the code is correct by checking that the output, generated using the test data inputs, is identical to the test data output.

The test data set below provides a few data points over the extent of the water column.

Input:

TIM YYMMDDhhmmss 25.3884 26.9384 24.3394 23.3401 22.9832 29.4434 26.9873 15.2883 16.3374 14.5883 15.7253 18.4383 15.3488 17.2993 10.2111 11.5993 10.9345 9.4444 9.9876 10.9834 11.0098 5.3456 4.2994 4.3009 BV: 11.5916 SN: 021968 FET<CR><LF>

L0 Temperature Array in Spatial Grid Output:

Instrument Timestamp (don’t use—use DigiPort timestamp)

24 Temperature values (stored as an array, but with the functionality during plotting or download as 24 parameters):
t1 25.3884
t2 26.9384
t3 24.3394
t4 23.3401

t5 22.9832
t6 29.4434
t7 26.9873
t8 15.2883
t9 16.3374
t10 14.5883
t11 15.7253
t12 18.4383
t13 15.3488
t14 17.2993
t15 10.2111
t16 11.5993
t17 10.9345
t18 9.4444
t19 9.9876
t20 10.9834
t21 11.0098
t22 5.3456
t23 4.2994
t24 4.3009

Metadata:
Battery Voltage 11.5916
Serial Number 021968

L1 Temperature Array in Spatial Grid Output:

Metadata fields from L0 (Battery Voltage and Serial Number) and Position Metadata from Position Matrix (See Appendix C)

1 x 25 array (the printed version below is wrapped to fit on the page), this array should have the full plotting and download functionality of a timestamp and 24 parameters (e.g. plotting of any or all of the 24 temperatures vs time, downloaded files that consist of a single row per timestamp):

timestamp	t1	t2	t3	t4	t5	t6	t7	cont..
2013-04-23T22:56:37Z	25.3884	26.9384	24.3394	23.3401	22.9832	29.4434	26.9873	
t8	t9	t10	t11	t12	t13	t14	t15	cont..
15.2883	16.3374	14.5883	15.7253	18.4383	15.3488	17.2993	10.2111	
t16	t17	t18	t19	t20	t21	t22	t23	t24
11.5993	10.9345	9.4444	9.9876	10.9834	11.0098	5.3456	4.2994	4.3009

Appendix A Example Code

Example matlab code:

Assume for each measurement parsed temperature data is in a 1x24 matrix “t”

```
%NaN is a common notation for “not a number”

L0T = NaN(24,1);  %NaN(a,b) is a function that creates an aXb matrix filled initially with NaNs

L0T= t(1:24) %Temperature results from parsed raw data stream

L1T = NaN(1:25);

L1T(1) = timestamp;
L1T(2:25) = L0T
```

Appendix B Output Accuracy

The accuracy of the L1 product is identical to the instrument accuracy.

The OOI-RSN requirements for the accuracy, precision, resolution and drift of the Temperature Array in Spatial Grid measurement, as represented in DOORS are:

> The diffuse fluid 3-D temperature array shall make fluid temperature measurements with an accuracy of 0.1°C. <L4-RSN-IP-RQ-202>

> The diffuse fluid 3-D temperature array shall make fluid temperature measurements with resolution of 0.1°C. <L4-RSN-IP-RQ-203>

From RBR XR-420 Logger and Thermistor Chain manual:

Range: +5°C to 50°C
Accuracy: ±0.005 ℃
Resolution: <0.00005 ℃

Appendix C Sensor Calibration Effects and Position Metadata

All instrument calibrations and available metadata, including sensor-specific calibration coefficients, thermistor coordinates, and sensor orientation, will be provided to users in the calibration repository on Alfresco:

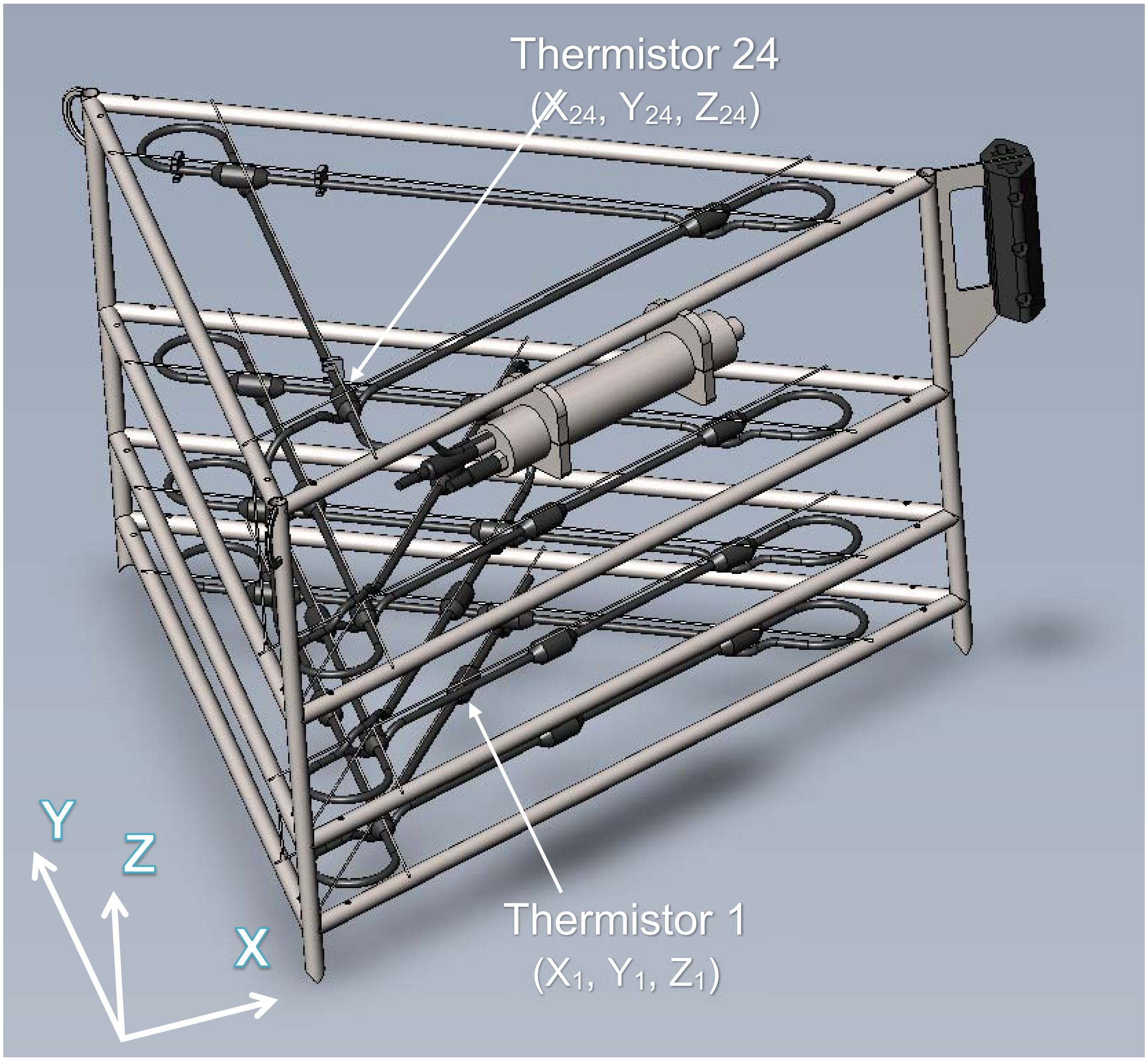
OOI > Instrument & Platform Documents > Calibration and Repair > Cabled Array > TMPSFA

This instrument is calibrated at the factory, resulting in a series of coefficients that allow for raw counts to be transformed into viable temperature values. The instrument data output in "real-time" mode is a temperature value that has been internally computed using the onboard calibration coefficients. Though the calibration coefficients are not necessary for obtaining L1 data products from the OOI system, these coefficients will be associated with each instrument instance deployment and provided to users for reference.

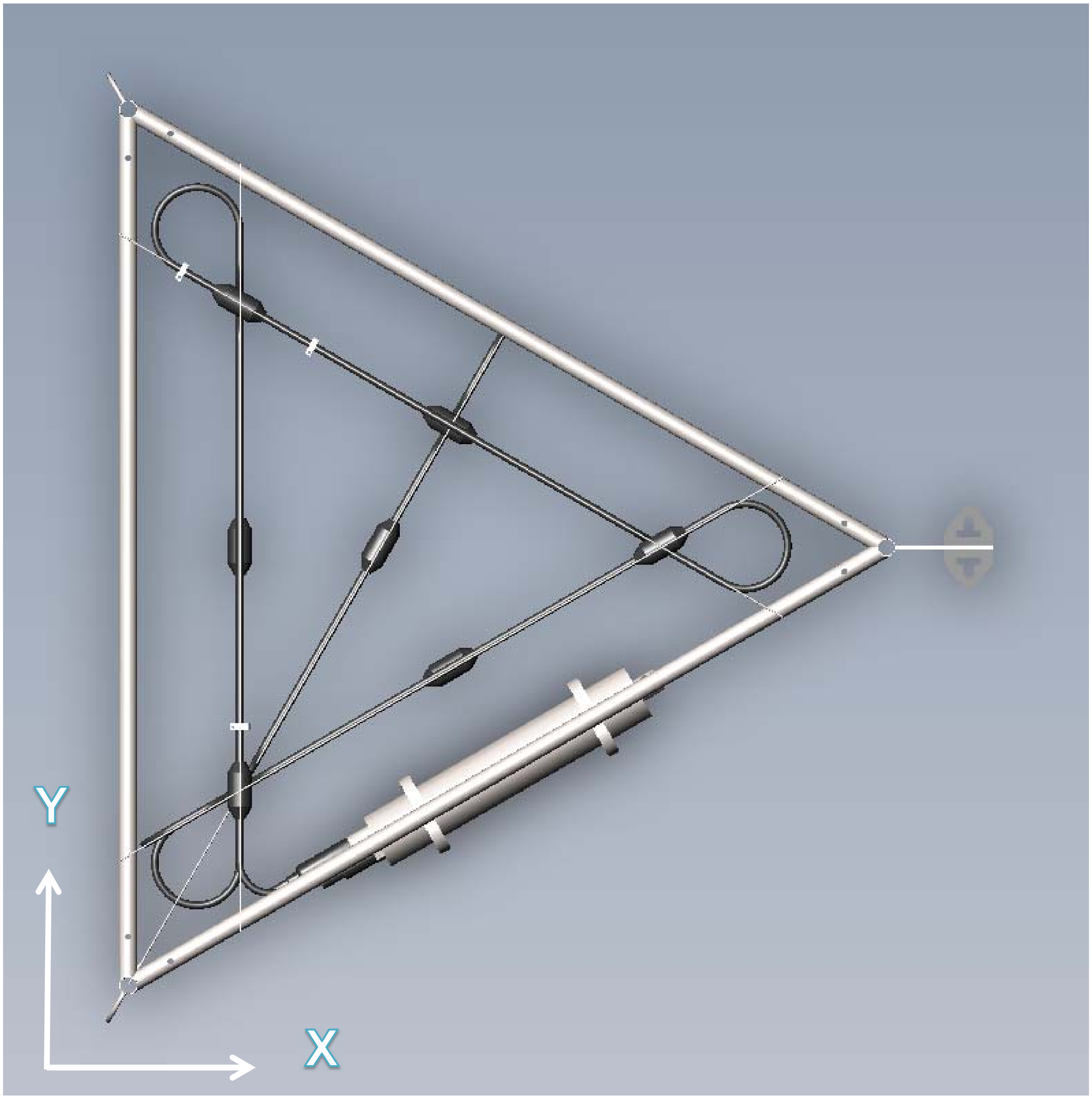
The position of each thermistor sensor will be updated with the physical construction of each individual instrument. Thermistor positions will be provided as a <24x3> matrix, with the row number corresponding to the thermistor number, and the columns representing x, y, z coordinates in relation to the origin, defined as the seafloor beneath thermistor #2. The y-axis is aligned with a line of sensors, specifically 22 and 24 (see Top View below). The z-axis orientation is relative to x-y plane and not in reference to height above the seafloor. Therefore, the z-axis does not compensate for seafloor irregularities or instrument tilt. Coordinates will be listed after each build/deployment as calibration values in the asset management repository.

The calibration metadata will also include the orientation, but not tilt, of the instrument on the seafloor provided as the compass heading of the x-axis. The x-axis heading is normally obtained using the heading of the ROV, reported in degrees relative to true North, in line with a portion of the instrument array in relation to the x-axis. For example, if the ROV heading observed in line with y-axis = 100°, the instrument heading in relation to its x-axis would be calculated as 100° + 90°= 190°. Details of heading calculations for each deployment will be provided to users in the calibration repository on Alfresco.

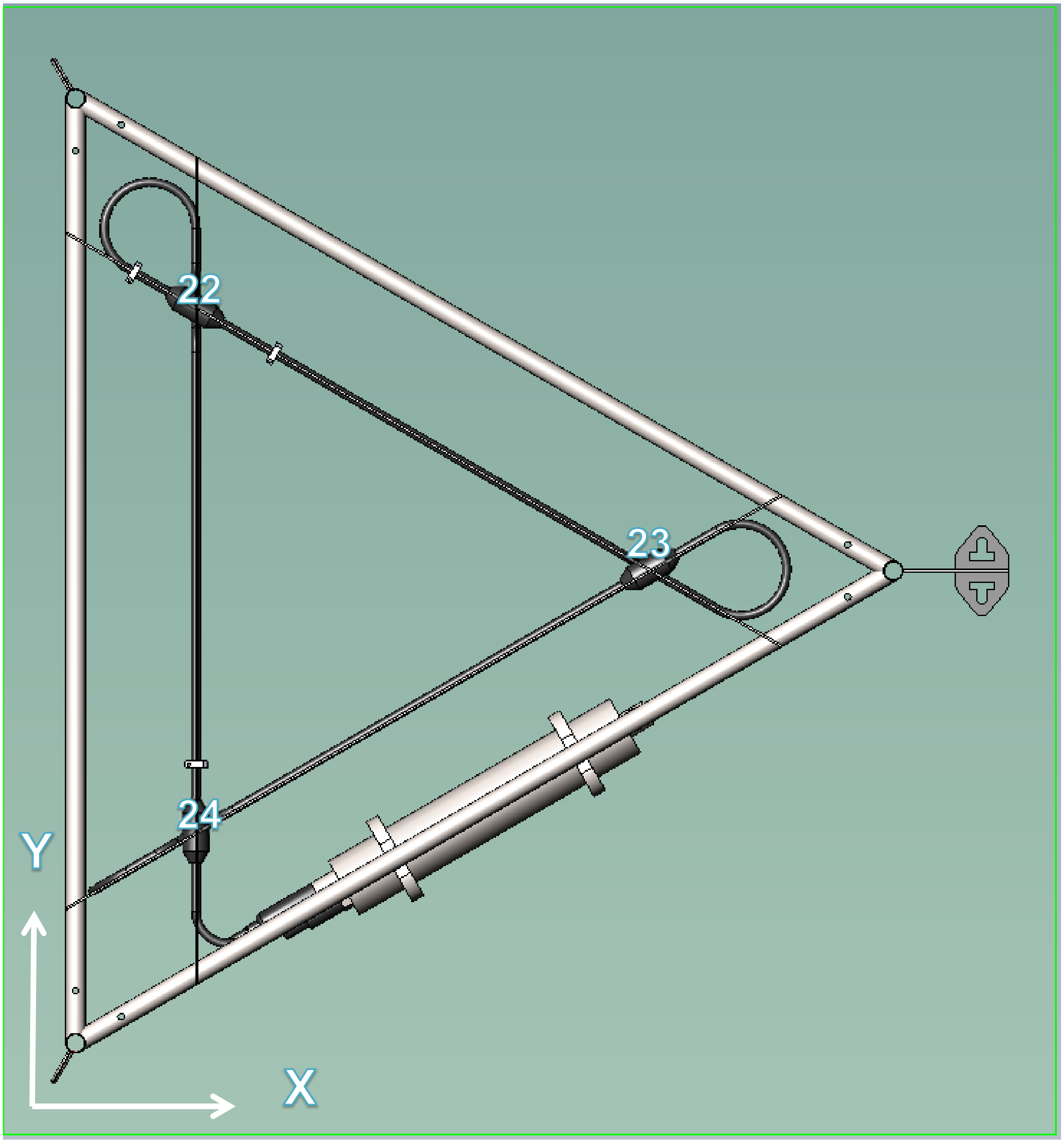
ISOMETRIC VIEW



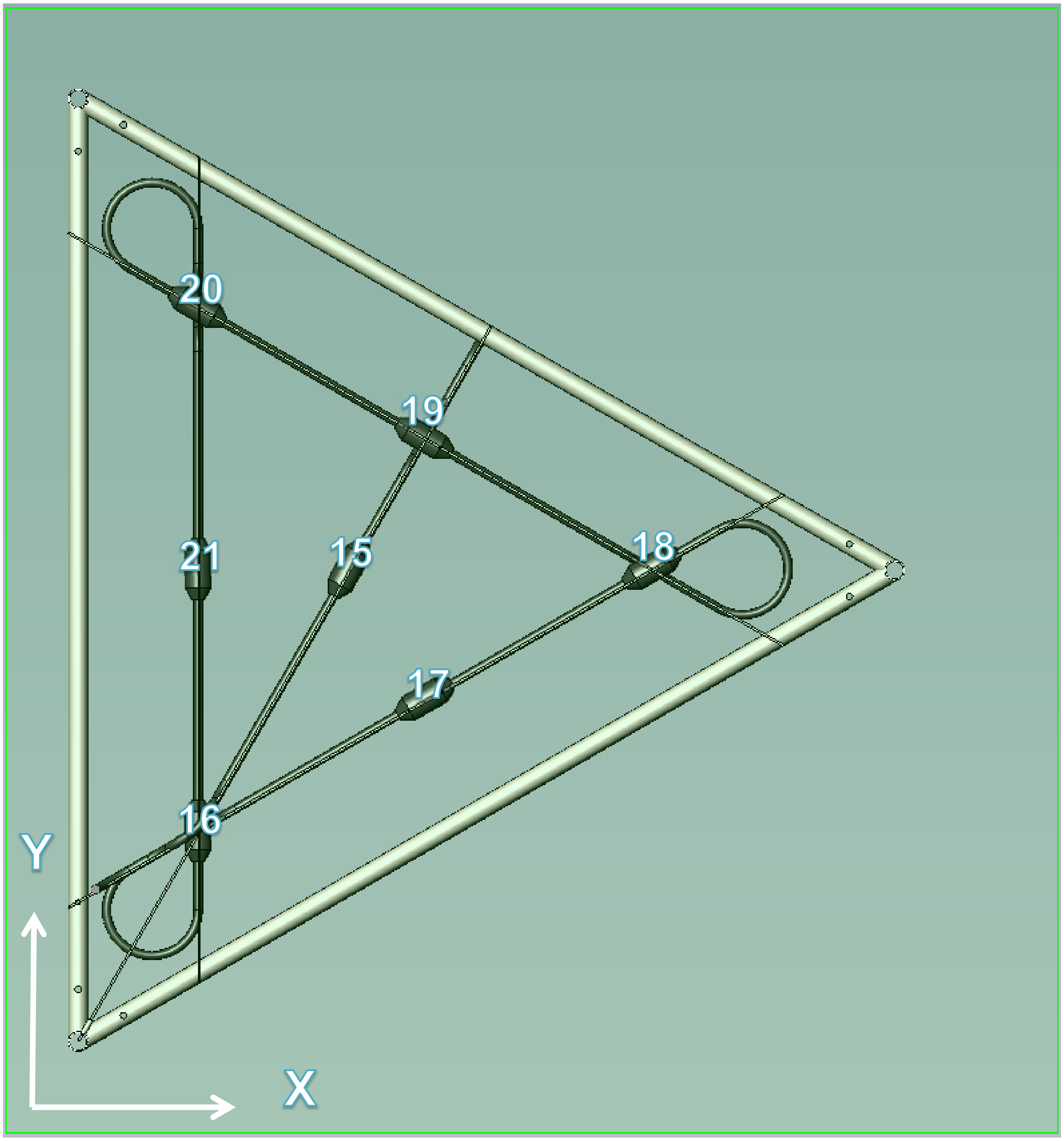
TOP VIEW



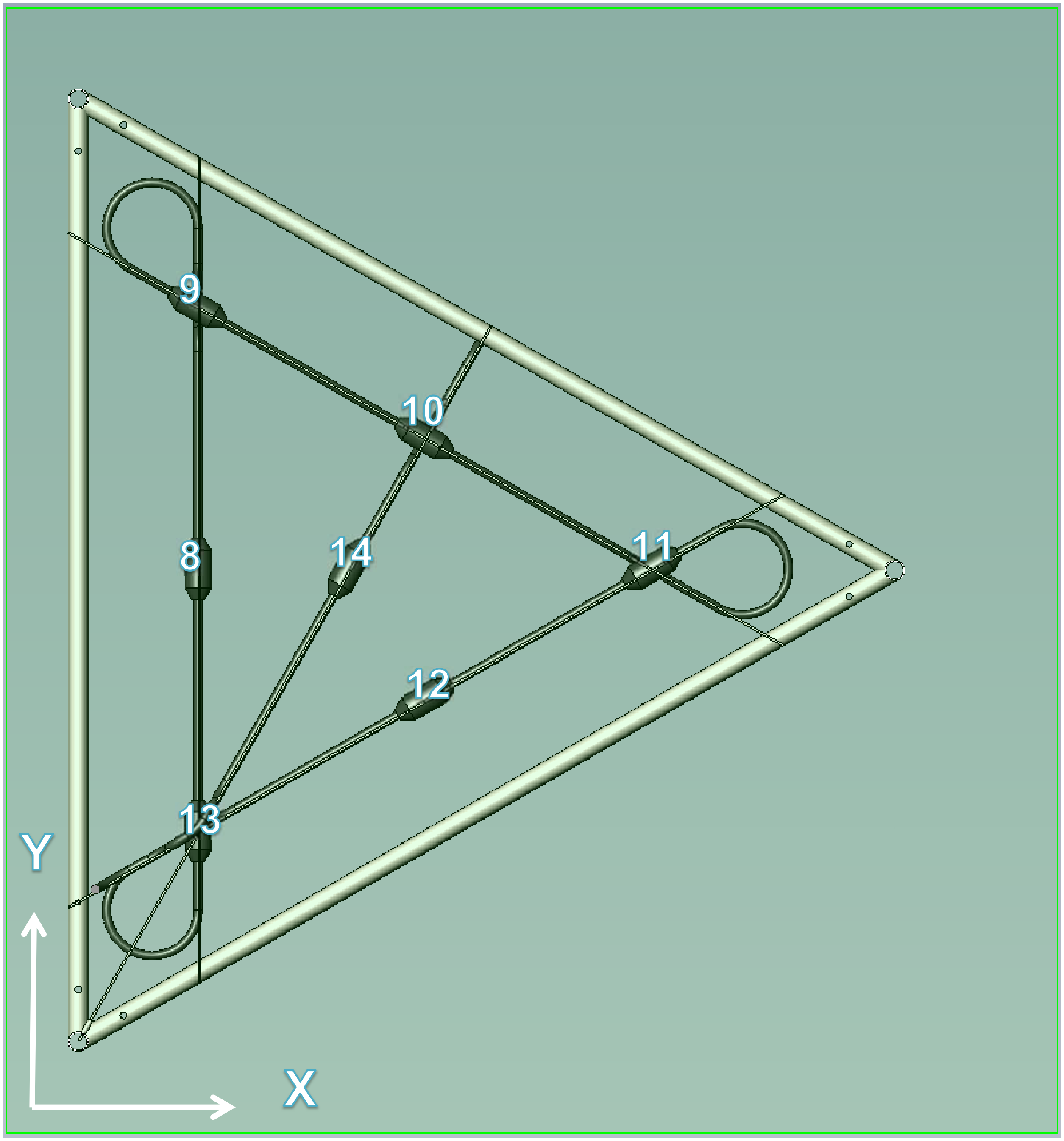
Top View, Level 4 (Top)



TOP VIEW, Level 3



TOP VIEW, Level 2



TOP VIEW, Level 1 (Bottom)